CLAIMS:

1. The method of treatment of a work product for improving life and load bearing strength, comprising the steps of:

applying to an external surface area in the vicinity of stress concentration regions of said structure by an impulse producing instrument in mechanical contact with the external surface a multiplicity of shock pulses of a magnitude and sequential relationship to induce temperatures to a predetermined depth in the structure, for inducing internal compression waves in a dynamic treatment zone of molten material,

inducing by reaction to said shock pulses in said dynamic treatment zone a compression wave pattern gradient of greater magnitude at a surface area than at remote locations in the work product body, and

withdrawing the shock pulses in a manner that substantially cools the treatment zone to establish reconstructed compression wave distribution patterns thereby producing a work product with higher fatigue strength and load bearing capacity.

2. The method of Claim 1 wherein the work body is a welded product with stress concentration regions in the vicinity of a weld seam being plasticized.

3. The method of Claim 1 having the specific objective of establishing relaxed internal stress patterns in the residual body material structure.

4. The method of Claim 1 having the specific objective of establishing a white layer effect in the residual body material structure.

5. The method of Claim 1 having the specific objective of establishing with a shock impulse producing transducer a gradient pattern of internal vibrations extending from a maximum vibration amplitude near the external surface area being treated to merge into said remote locations of substantially unvibrating body material, and wherein the step of withdrawing the shock pulses external surface vibrations to cool the treatment zone is achieved by movement of the transducer on the external surface area.

6. The method of Claim 1 undertaken by withdrawing the shock pulses at a rate producing a manufactured product body having fewer voids in said dynamic treatment zone.

7. The method of Claim 1 undertaken by withdrawing the shock pulses at a rate that relaxes residual internal product body stress patterns induced by aging and fatigue conditions encountered in use.

8. The method of Claim 1 undertaken to repair visible aging and fatigue defects observable on the product.

9. The method of Claim 8 wherein the product is a load bearing member in a bridge structure, and wherein the method is undertaken with traffic moving over the bridge structure.

10. The method of Claim 1 wherein the shock pulses are applied to said external surface zone on an untreated work product surface without preliminary surface treatment.

11. The method of Claim 1 undertaken on a product with a metallic body.

12. The method of Claim 1 undertaken on a ferromagnetic body material.

13. The method of Claim 1 wherein the work product is a welded product displaying a weld seam and the shock pulses are applied alongside a weld seam to create the internal compression waves at a weld seam interface region.

14. The method of Claim 1 further comprising the step of moving the vibrating instrument over a path configuration on said external surface.

15. The method of Claim 14 further comprising the concurrent step of moving a welding device over a corresponding path on said external surface to produce a molten pool merging with the molten material zone induced by said internal compression waves.

16. The method of Claim 1 wherein the interior compression waves are ultrasonically induced.

17. The method of Claim 1 wherein the step of withdrawing the shock pulses comprises moving said impulse producing instrument over a predetermined path pattern on the external surface.

18. The method of Claim 17 further characterized by the steps of generating said shock waves at a driving frequency of 18 to 25 kHz during movement of the impulse producing instrument along the external surface at a treatment mode speed of 0.3 to 0.7 m/min.

19. The method of Claim 17 further comprising the step of automating the movement of said instrument in a step by step movement mode over said predetermined path pattern.

20. The method of Claim 17 further comprising the step of moving the instrument along said path with a positioning mechanism jig.

21. A product body with the internal body structure established by the method of Claim 1.

22. The method of Claim 1 further characterized by creating the shock pulses with an impact producing instrument comprising a transducer driven at a controllable oscillating frequency when in contact with the surface of a welding structure, driving the transducer into an oscillating mode with a periodic source of pulse energy at a frequency corresponding to a natural mechanical resonance condition of the instrument at work on the surface, periodically detecting a feedback signal at the interface of the instrument showing frequency and phase of the natural mechanical oscillating frequency, and adjusting the oscillating driving source frequency and phase to that of the sampled mechanical resonance condition.

23. The method of Claim 1 further characterized by a transducer displaying a resonant drive frequency during work on the product surface, applying said shock pulses periodically at the resonant drive frequency, utilizing a feedback signal from the transducer to correct the frequency and phase of the drive frequency to the transfer resonant drive frequency and phase,

thereby to effectively transfer ultrasonic energy from the transducer into the work product interior.

24. The method of Claim 1 further characterized by the step of applying said shock pulses in the form of pulsed ultrasonic energy with a manually applied ultrasonic transducer impact tool non-destructively contacting said external surface.

25. The method of Claim 1 further characterized for treatment of metal products by the step of creating a compressing/compression stress at said surface area for plasticizing the metal and redistributing stress distribution patterns in internal zones thereby to create internally a substantially grain free white layer zone.

26. The method of Claim 1 further characterized by the step of applying the method in an initial welding production stage of a welded body product to produce a welded structure with higher fatigue strength and higher load bearing strength.

27. The method of Claim 1 further characterized by the step of applying the method in a maintenance stage in the interim life of a welded structure in service to improve fatigue resistance and fatigue corrosion resistance.

28. The method of Claim 1 further characterized by delivering said shock pulses with a manual impact tool in external surface working contact with the welded structure.

29. The method of Claim 1 further characterized by treatment of a catastrophic failure region in a welded body structure with ultrasonically reproduced said shock pulses to remove stress

concentration regions in a welding repair step by applying said shock pulses in the vicinity of a weld seam.

30. The method of Claim 29, wherein the catastrophic failure comprises a visible crack located on the external surface of the welded body further characterized by the step of mechanically chamfering the lips of the crack and thereafter welding to repair the crack.

31. The method of Claim 29 further characterized by the steps of identifying the end regions of a visible crack located on the external surface of the welded body, and before welding the crack, mechanically drilling holes in the end regions of the crack of a predetermined minimum diameter for achieving significant reduction in spreading of the crack.

32. The method of Claim 31 further characterized by the step of mechanically chamfering surface edges of the holes drilled in the end regions of the crack before welding.

33. The method of Claim 29 further characterized by the step of welding on the surface area a bracing member adjacent the crack while applying said shock pulses about a weld seam attaching the bracing member.

34. The method of treating internal solid body structure of a load bearing member with recurring vibrating pulse impacts on the body structure interior surface from a vibrating transducer tool of a magnitude pulse length and recurrence rate inducing internal residual compressive waves and plastic deformations in a zone inside said solid body structure leading to relaxation and

distribution of residual internal body structural defects, withdrawing pulse impact energy being induced inside said body to return the body structure zone to a reformulated solid state, deriving from operating characteristics of said tool in the vibrating state a feedback signal indicative of the dynamic internal body state in said zone, and modifying the reaction of said pulse impacts on the body structure external surface to more effectively establish a predetermined inner solid body reformulated solid state.

35. The method of reducing structural defects in manufactured work products comprising the steps of:

inducing interior mechanical vibrations in a dynamic treatment step with a vibrating instrument contacting an external surface zone of the work product and drive with mechanical impulses of an energy, pulse shape, magnitude and repetition rate sufficient to reform resident normally solid interior work body material,

sensing interface loading conditions at said external surface zone during dynamic treatment to determine changes in the nature of internal body structure,

controlling the energy, magnitude, pulse shape and repetition rate of mechanical vibrations at the surface zone in response to the sensed changes of internal body structure, and

establishing an internal body structure condition for withdrawing the interior mechanical vibrations in a manner reestablishing a modified interior solid body material structure.

36. The method of Claim 35 further comprising the step of automatically coordinating the step of controlling the energy and timing of the mechanical vibrations with a specific objective of establishing a predetermined terminal residual body material structure.

37. Apparatus for impact vibrating treatment of load bearing work product bodies for establishing internal body structural conditions favoring greater strength and longer life, comprising in combination:

a source of repetitive impulse energy,

a transducer adapted to introduce pulse energy from said source by mechanical contact at an external body surface to generate in an interior zone of a solid shaped product body structure corresponding compression wave energy of a magnitude pulse shape and repetition frequency that converts a zone encompassing internal body material into a molten state without distorting the external residual shape of the product body,

and means for withdrawing said impulse energy by positioning said transducer thereby to restore the solid body structure in said zone and produce in said zone restructured body characteristics presenting reduced structural defects and reduced residual stresses.

38. Apparatus as defined in Claim 37 for processing a work product comprising a welded body exhibiting a welding seam, further comprising means for positioning said transducer on an external work product surface in a position to treat internal body structure

a zone encompassing an interface between the welding seam and unwelded product body material.

39. Apparatus as defined in Claim 37, further comprising welding means for creating a welding seam pattern along an external surface of said product body, wherein the means for positioning said transducer is coordinated to move concurrently along the body surface to follow the creation of said weld seam pattern, thereby further comprising said means for withdrawing said impulse energy from already treated said zones.

40. Apparatus as defined in Claim 37 further comprising means for deriving from said transducer feedback signals representative of the internal body material state during dynamic changes of state induced inside said product body by said compression wave energy, and means responsive to said feedback signals for modifying the nature of the input energy delivered by said source to the transducer.

41. Apparatus as defined in Claim 40 wherein said means responsive to feedback signals fashions periodic impulse energy of a frequency, pulse length and phase matching a mechanical resonance frequency of a vibrating transducer at work in contact with the external body surface.

42. Apparatus defined in Claim 37 wherein the transducer comprises an ultrasonically vibrating transducer mechanism coupled to said external body surface by a wave guide for transmitting wave energy impulses terminating in a contact probe structure for contacting a work body surface interface.

43. Apparatus defined in Claim 42 wherein the wave guide comprises a body surface interface adapted to contact difficult to reach areas of treatment of work product bodies in an efficient energy transfer configuration.

44. Apparatus as defined in Claim 37 wherein said transducer comprises a peen in contact with said external surface for receiving impact impulse blows at a transducer-peen interface junction.

45. A load bearing work product body of a solid structural material having an interior structural zone having been reworked in a molten state induced by ultrasonically reproduced repetitive mechanical impulse impacts on an exterior work product body surface to form relaxed residual stress patterns and reformed grain boundary structure.

46. The work product body of Claim 45 exhibiting a white layer in said zone.

47. The method of ultrasonically treating a work product body by mechanical impulse contact of an ultrasonic vibrating instrument on an exterior body surface, comprising the steps of:

driving the ultrasonic vibrating instrument with a periodic series of driving impulses,

deriving from vibrations of said instrument when in working contact at a location on said exterior body surface during an interruption in said driving pulses a signal denoting mechanical motion of said exterior surface at said location, and adjusting the

periodic driving impulses to conform in frequency and phase with the derived signal.

48. The non-destructive method of detecting dynamic internal structural conditions of a work product being internally heated by input compressive wave impulse energy introduced at an external surface position on the work product characterized by sensing responsive vibrations at said external surface position to derive a signal representative of the work product internal structural condition variations from the input compressive wave.

49. The method of Claim 48 further characterized by the step of controlling the input compressive wave impulse energy as a function of the derived signal.